Proton Source Workshop – Dec 7-8, 2010
Wed AM Session Notes

edited by Ron Moore and Jim Steimel

PreAcc/Linac Downtime Statistics – *Fernanda Garcia*

Fernanda summarized the sources of PreAcc and Linac downtime over the past 10 and 30 years. Over the past 10 years, 68% of downtime was attributed to Linac RF systems and 11% from Pre-Acc. (Since 1977, those numbers are 71% and 15%, respectively.) The overall availability for Linac has been 89% over the past 10 and 30 years. 80% of the Linac RF downtime incidents in the past 10 years had a duration of 1-5 minutes. It is not obvious that the increased beam flux/rep rate is causing additional failures or more downtime. It was suggested to study the "mean time between failures" (MTBF) to help the evaluation. Environmental concerns include PCB-based capacitors in the quad power supplies and mercury in ignitrons within the modulator capacitor banks; catastrophic failure of these components could result in extended downtime for clean up. The PCB capacitors are being replaced gradually.

Booster Downtime – *Todd Sullivan*

Todd outlined the Booster downtime during 2010. The downtime *percentage* statistics from the D18 applications can be misleading – better to look at absolute number of hours. The RF system is the dominant source (75%) of this "no beam" downtime, but clearly the gradual RF voltage degradation between PA replacements causes decreased efficiency and higher beam losses. The overall 1.7% downtime in 2010 may seem acceptable to bureaucrats, so other important impacts must be communicated clearly: reduced proton flux and dose rate on technicians who work in the tunnel. Recent major repairs include the ceramic vacuum leaks on BRF 19 and BRF 3, water leaks on tuners of BRF 1, 15, 18. The ceramic vacuum leaks are particularly troublesome since those are the first seen of those problems, the cavities must be removed from the tunnel for repair, and techs pick up considerable dose during the repair. Proactive maintenance is performed regularly. There is an ongoing campaign to replace plastic water tubing and O-ring with better, radiation-hardened components. The power supplies and controllers for the new corrector magnet system are more reliable and contemporary, so obtaining spare parts is not an issue. The increasing demand on flux and rep-rate strongly motivate the need for upgrades to infrastructure, RF power supplies, and the cavities themselves.

Linac Momentum Dump – *Rob Reilly*

Rob described the history and vacuum problem with the Linac 400 MeV/c momentum dump. This dump, installed in 1969, developed a vacuum leak in late 2007 likely caused by ground water seeping into the vacuum region. A window was installed to isolate the dump vacuum from the rest of the 400

MeV line, but it is not a long-term solution; the window seal failed in early 2009. A roughing pump maintains the dump vacuum to 10^{-2} to 10^{-3} torr to inhibit tritium production. Since the window was installed, the surrounding tunnel region is a high-radiation area and complicates maintenance on the nearby transfer line components. Using the existing straight-ahead dump is not an option because it cannot tolerate the beam flux. A number of solutions have been proposed including: dig up and repair existing dump, dig up and replace the dump, construct a new dump, insert a vacuum sleeve inside the existing dump (favored). Design of a sleeve insertion is complicated since the original drawings are not quite 100% "as-built" as discovered when bore-scoping the dump. There are likely lumps on the inner steel surface left over from the casting process during manufacturing. Getting a snug mechanical fit to the existing steel is important for thermal conduction. Mechanical design of the sleeve is ongoing.

Linac Power Tubes – *Fernanda Garcia*

Fernanda described all of the tubes currently used in the PreAcc/Linac and estimated how long we can run the system given the spare inventory and possible production. There are 16 different vacuum tube designs (8 different manufacturers) – 93 tubes altogether needed to run the machine. There is no concern for the 3 tube styles needed for PreAcc; only the Extractor pulser tube (Richardson) will be needed after RFQ installation. There is also no concern regarding the klystrons and ignitrons used in the high-energy linac; ample spares on hand, new tubes readily available. Two tubes for the low-energy linac are considered a threat to long-term operation: the F-1123 modulator switch tubes and the 7835 tetrode power amplifiers. The F-1123 are no longer in production; rebuilds are possible – 2 failed tubes to make 1 good rebuilt tube. A possible replacement tube (F-1046) has not yet been tested in our system. Our F-1123 inventory will likely be depleted within 6-11 years. Burle still produces the 7835, but the lifetime of recent new tubes has decreased and the company's long-term plan is not clear. The lab's contract with Burle is renewed annually. Rebuilds are possible with an uncertain success rate and lifetime. If Burle stops producing new <u>and</u> rebuilt 7835 tubes now, our inventory will be depleted in 2 years; continued rebuilds with no new tubes extends the inventory to10 years. The bottom line is that we likely have less than a 15 year supply of tubes to operate the Linac.

Linac Front-end Upgrade – *C-Y Tan*

Tan summarized progress on the design and testing of the front-end upgrade: new style H^- source and 750 keV RFQ. The upgrade essentially is a reproduction of the very successful source now used at BNL to improve reliability and beam quality downstream. A "dimple source" should not clog like our current "slit source" and allow higher beam current for the same arc. As a test, the HINS H^- has been modified and tested with an Einzel lens used as a chopper; initial tests look promising, <50 ns chopper rise time. The LEBT (low-energy beam transport) into the RFQ is designed to be short – only 1.2 m long and allow switching between 2 sources (1 as a spare) on a single platform readily when needed. The LEBT focusing solenoids should be delivered in early 2011. The RFQ has been designed and simulated; delivery also expected in early 2011. The MEBT (medium energy beam transport) that will take beam from the RFQ into Linac tank 1 is still being designed. It will have quad doublets for focusing before/after the buncher; the issue is choosing between shorter BNL quads (water cooled) or longer FNAL quads (air cooled, with dipole correctors). The goal is to have a complete system test by the end of 2011 and installation (3 months) in 2012. An external review or two are expected along the way.

Booster Magnet Status – *Jim Lackey*

Jim surveyed the status all magnets in the Booster system (including 400 MeV line and the first 110 m of the MI8 line). There are no concerns for the various 400 MeV and 8 GeV line magnets; spares are available. The 96 combined-function Booster gradient magnets are the greatest concern due to their age and ever increasing radiation dose. None of those magnets have failed as a result of a coil failure, but there is fear of eventual insulation breakdown especially in high radiation areas near the extraction region and collimators. There are 5 spare gradient magnets: 2 under high vacuum, 1 under rough vacuum, 2 in repair at Technical Division. TD has been able to repair vacuum leaks in the skins by brazing. They are also developing replacement bellows and flanges. Jim's biggest fear is mechanical damage to a magnet during realignment (not disconnecting everything properly before moving). The resonant capacitors for the magnets are readily available should one fail. All original magnetic measurements of the gradient magnets have been lost. If a gradient magnet needed replacement, one might consider just replacing the whole girder with all components, but there are no spare girders currently. Other system failures that have occurred and remain a concern include the extraction kickers (radiation damage) and the extraction septa.